

supply. If necessary, replenish the test fuel by adding one ounce (30 ml) of fluorescent dye for each gallon (3.79 liters) of make-up diesel fuel. Normally, three to five units can be tested before replenishing the fuel.

4. With the engine idling and the rocker covers removed, shine the "black light" over the head assembly. Lube oil will show up as a dull blue. A fuel leak will glow a bright yellow. This type of test is best conducted in a darkened or shadowed area. The darker the area surrounding the unit being tested, the easier it is to see the fluorescent dye.
5. If bright yellow dye is detected, determine the cause of the fuel leak and eliminate it. Wipe the cylinder head and fuel connections clean, start and idle the engine and recheck the head area.

6. When all leaks have been eliminated, reinstall the original fuel lines and connect the engine to its normal fuel source. It is not necessary to change the fuel filter or strainer. Start and run the engine to purge any air from the fuel system.

Normal Fuel Weepage

Some fuel weepage may normally be encountered from the follower and/or rack on DDC injectors while performing this test. Special consideration must be given to this weepage and the fact that it should not be allowed to exceed the DDC guidelines for pressure holding test (see Section 2.1.1) and the specification for lube oil dilution (2.5%).

Since all leakage or spillage of fuel during leak detection testing dilutes the lube oil, the final step in maintenance of this type should include lube oil and lube oil filter changes.

• FUEL JUMPER LINE MAINTENANCE

Maintenance and service personnel should be aware that severe engine damage could result from fuel oil leakage into the lubricating oil and should therefore, follow proper procedures when removing, handling and installing fuel jumper lines (fuel pipes).

The fuel jumper lines which carry fuel to and form the fuel injectors must be handled and installed very carefully to prevent line damage that can result in severe engine damage. Severe fuel leakage, if not detected, can also result in an over-filled crankcase (oil pan) which can cause an abnormal amount of fuel and lubricating oil vapor to escape from the engine and crankcase breathers. An abnormal concentration of fuel and lube oil vapors is flammable and could ignite in a closed engine compartment.

The following are some of the conditions that can result in fuel jumper line leakage:

1. Improper handling and storage of jumper lines when servicing the engine can result in physical damage and contamination.
2. Careless use of special tool (socket) J 8932-01 during removal or installation can cause a jumper line to bend and be permanently distorted.
3. Reuse of a bent or distorted jumper line can result in excessive stress and cause the line to crack or fracture at or above the flared ends of the jumper line. A fuel leak will ultimately result.
4. Excessive tightening of the jumper line nut will distort and fracture the flared end of the jumper line, resulting in a fuel leak.

● **NOTICE:** DDC recommends that the original fuel pipes not be reused. New flared end

fuel pipes should be installed. When installing flared end fuel pipes, use fuel pipe nut wrench J 8932-01 and "clicker" type torque wrench J 24405 (calibrated in inch-pounds) to apply proper torque and avoid damaging the fuel pipes. Refer to the chart for torque specifications. Fuel leakage from damaged or improperly installed fuel pipes can cause lube oil dilution, which may result in serious engine damage.

To help insure more consistent fastening, tighten fuel pipe nuts on jumper lines to the single torque values shown below. Use fuel line nut wrench J 8932-01 and "clicker" type torque wrench J 24405 (calibrated in inch-pounds).

NOTICE: Because of their low friction surface, Endurion®-coated nuts on fuel jumper lines must be tightened to 130 *lb-in* (14.69 N·m) torque, instead of the 160 *lb-in* (18.3 N·m) required with uncoated nuts. To avoid possible confusion when tightening jumper line nuts, do not mix lines with uncoated and Endurion®-coated nuts on the same cylinder head.

Jacobs brake jumper lines and jumper lines used with load-limiting devices do not have coated nuts. Tighten these to the values shown on the Chart.

NOTICE: When installing fuel jumper lines, *Do Not Overtighten*. Damage to the jumper line flares and connector seats can result from excessive tightening, causing fuel leakage into the lubricating oil.

Fuel Pipe Usage	Torque
Endurion®-coated	130 lb-in. (14.69 N·m)
Uncoated	160 lb-in. (18.3 N·m)
Jacobs Brakes*	120 lb-in. (13.6 N·m)
Load limiting devices	160 lb-in. (18.3 N·m)

*Not serviced. Available from Jacobs Manufacturing Company.

Jumper Line Nut Torque Chart

- Damaged threads and flare seats on the injector and cylinder head jumper line connectors can also result in fuel leakage.
- Leaks can also occur at injector filter nut gaskets and/or cylinder head connector washers due to distortion, damage or incorrect torque.

The following troubleshooting procedure is recommended after installation of fuel jumper lines and/or connectors to determine if fuel leakage is present.

Checking for Fuel Leaks

Always check the fuel system for leaks after injector or fuel jumper line replacement and any time the fuel connections under the rocker cover are suspected of leaking. Failure to correct a fuel leak in this area can lead to dilution of the lube oil. Use one of the following methods to check for leaks.

METHOD A

Use when the engine has been operating 20–30 minutes. After operating the engine, shut it off and remove the rocker cover(s). Discard the gasket(s). Inspect the lube oil puddles that normally form where the fuel connectors join the cylinder head and where the fuel jumper lines join the fuel line nuts.

If there is any leakage at these connections, the lube oil puddles will be smaller or thinner than the puddles on the connectors that are not leaking. Disassemble, inspect and correct or replace the suspect part (connector washer, connector, injector or jumper line). Test and reinspect.

METHOD B

Use when the engine is not operating such as during or after repairs. Remove the rocker cover(s). Discard the gasket(s). Pour clean lube oil over the fuel jumper lines and connectors which would normally be splashed with oil during engine operation. This will cause oil puddles to form at the joining surfaces as mentioned in Method A. Plug the

fuel return line at a convenient location (cylinder head or fuel tank, for example). Disconnect the fuel pump supply line at the inlet of the secondary filter. Connect an external source of pressurized fuel (60–80 psi or 414–552 kPa) to the inlet of the secondary filter cover. Install a pressure gage (0–100 psi or 0–689 kPa) at the outlet of the filter cover. Gage installation can be accomplished by installing a “T” fitting between the filter cover and outlet line or by removing the pipe plug at the outlet in the cover. Use of a gage will allow ready reference to the fuel pressure being maintained for this test. Severe leaks are immediately visible and minor leaks take longer to appear. It may be necessary to maintain fuel pressure for a period of 20 to 30 minutes in order to find minor leaks. Leaks may be repaired by replacing damaged parts or determining if the part is loose and below torque specifications. Test and reinspect.

If injectors are suspected of leaking and contributing to dilution of the lube oil, they should not be tested by pressurizing the fuel system as in Method B. Injectors should be removed from the engine and high pressure tested as outlined in Section 2.1 or 2.1.1.

METHOD C

Use while the engine is operating at 400–600 rpm. Apply an outside fuel source capable of 60–80 psi (414–552 kPa) to the outlet side of the secondary filter. Pour lube oil over the fuel jumper lines and connectors so that oil puddles form where jumper lines and connectors meet. Install a valve and a pressure gage in the fuel return line. With the engine idling, close the valve enough to raise the engine fuel pressure to 60–80 psi (414–552 kPa). After 10–20 minutes, inspect the oil puddles to see if any have become smaller or run off completely. The undiluted oil will hang the same as when the oil was poured on. Repair and retest.

Slightly worn injector plungers may leak more under these conditions. This leakage will not occur while the engine is running because of the dynamic and pressure conditions that exist.

METHOD D

Fluorescent dye fuel leak testing. When testing an engine that has been in service, it will be preferable to use the fluorescent dye and black light method of testing. Proceed as follows:

- Mix 4 oz. of fluorescent additive J 28431 with 4 gallons (15 liters) of clean diesel fuel (#1 or #2) in a clean container. The container should be marked “Test Fuel” and be resealable so that it won’t be contaminated when not being used.
- Isolate the engine fuel system so that the supply and return fuel lines are connected only to the test fuel container. It will be necessary to intermittently check the fuel level to maintain an adequate supply.
- Warm up the engine by operating it at maximum no-load speed for approximately 15 minutes.